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PROV

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Elias JONSSON et al.

Title of Invention: Optimal Scaling of RAKE Output Symbols for WCDMA

Attorney Docket No.: 47253-00064USPL

Box Provisional Patent Application
Commissioner for Patents
Washington, D.C. 20231

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☒ Transmitted herewith is a Provisional Patent Application under 37 C.F.R. § 1.53(c) as identified above.

☐ Transmitted herewith is an Assignment to Telefonaktiebolaget LM Ericsson (publ) along with Form PTO-1595 Assignment Recordation Sheet. **Please return the recorded assignment to the undersigned.**

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☐ Applicant(s) claim(s) small entity status under 37 CFR 1.9 and 1.27.

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Respectfully submitted,

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Date: Feb 4, 2003

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PROVISIONAL APPLICATION COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION under 37 C.F.R. § 1.53(c)

Docket Number: 47253-00064USPL	Type a plus sign (+) inside this box →	+

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TITLE OF THE INVENTION: **Optimal Scaling of RAKE Output Symbols for WCDMA**

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ENCLOSED APPLICATION PARTS (check all that apply):

- ☒ Specification — *Number of Pages* **8**
- ☒ Drawings — *Number of Figures* **5**
- ☐ Small Entity Statement
- ☐ Other : ____________

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Filing Fees Due for Provisional Application:
☒ $160.00
☐ $80.00

Was the invention made by an agency of the United States Government or under a contract with an agency of the United States government?

☒ No.

☐ Yes, and the name of the U.S. Government agency and the government contract number(s) are:

Respectfully submitted,

Stanley R Moore

DATE February 4, 2003

NAME Stanley R. Moore

REGISTRATION NO. (if appropriate) 26,958

☐ Additional inventors are being named on separately numbered sheets attached hereto.

PROVISIONAL APPLICATION FILING ONLY

~~Applicant(s) herein make claim to a new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof as substantially shown or described herein.~~

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Optimal scaling of RAKE output symbols for WCDMA

Technical Field of the Invention

The invention relates to a method of scaling the RAKE output symbols in a WCDMA receiver. The invention also relates to a corresponding receiver system.

Description of Related Art

In a WCDMA receiver system, see Figure 1, the radio signal is first down converted to base band by the radio interface, not shown in the figure. Then the analog signal is scaled by the automatic gain control (AGC), Block 101, before being quantized by the analog to digital (A/D) converter, Block 102. The signal from the AGC is scaled to keep the average power of the sum of the I and Q parts as close as possible to a given reference value. The measured power could be taken before or after the A/D converter. Usually, some kind of control algorithm is involved in finding the optimal scale factor for the AGC. We assume that such an algorithm is given.

Once the received signal has been quantized it is despread in the RAKE. A radio signal could have travelled through different paths before arriving at the receiver, which causes the signal to be received at different time delays. Given the time of arrival of each path, we despread the received quantized signal in the RAKE, Block 103, for each path. In the RAKE, we multiply the quantized signal, sampled at chip rate, with its corresponding channelization code and scrambling code and sum over the length of the channelization code.

To minimize silicon area, as few bits as possible should be used to represent the output from the truncation and saturation block 104. In Figure 1, we assume that g_I and g_Q are represented with N_g bits. Here, t_I or t_Q is computed from g_I or g_Q by extracting the N_t least significant bits if this still equals g_I or

g_Q. Otherwise, we have overflow and t_I or t_Q is set to the maximum or minimum representable value of t_I or t_Q, which depends on the sign of g_I or g_Q. By saturating the signals t_I or t_Q, we partly solve the problem of overflow. However, if only one of t_I or t_Q saturates, we will loose valuable phase information between g_I or g_Q, see Figure 2. If both t_I and t_Q saturates, we loose even more phase information, since only four phases are possible, see Figure 3. In both cases, we loose valuable soft information, which results in a deteriorated performance. In Block 105 the radio channel estimates are calculated and their conjugates are multiplied with the despread data symbols. The products are then summed over the number of paths. Finally, in Block 106 the bit stream is decoded.

The problem with the current state-of-the-art solution is that we loose valuable soft information if we want the RAKE output to be represented with a small number of bits. The result is a deteriorated performance.

<u>Summary</u>

In the invention, we propose a method to adaptively select the reference power value for the AGC or to scale g_I and g_Q with a reference scale factor before truncation and saturation in Block 204. The reference power level and the reference scale factor depend on the strength of the signal output from the RAKE. In Figure 4, we show an overview of the proposed system. Here Block 207 adjusts either the reference value in the AGC or the truncation and saturation done in Block 204.

With the proposed solution, we adjust the average size of the values output from the RAKE to obtain optimal performance.

<u>Brief Description of the Drawings</u>

The invention will now be described more fully below with reference to the drawings, in which

Figure 1 shows an overview of the receiver,

Figure 2 shows in a dotted box the maximum values of t_I or t_Q. In the figure the coordinate (g_I, g_Q) fall outside the box and will thus be truncated. The result of the truncation and saturation is shown as the coordinate (t_I, t_Q). It is immediately seen that the truncation and saturation introduces a phase error,

Figure 3 shows in a dotted box the maximum values of t_I or t_Q. In the figure both g_I and g_Q fall outside the box and will thus be truncated. The result of the truncation and saturation is shown as the coordinate (t_I, t_Q), which will be located at one of the corners of the box. It is immediately seen that the truncation and saturation introduces a phase error,

Figure 4 shows the proposed modified receiver structure, and

Figure 5 shows a flow diagram of Block 207.

<u>Detailed Description of Embodiments</u>

Let $|x|$ mean the absolute value of x. Let x be a number represented by an integer number of bits N_x. Define M_x and m_x to be the maximum and minimum achievable number using the bit representation of x. Let y be represented with N_y integer bits. Define the truncation of x using saturation as

$$y = sat(x) = \begin{cases} M_y, & x \geq M_y, \\ x, & m_y < x < M_y, \\ m_y, & x \leq m_y. \end{cases}$$

Let the integer part of the number x be represented as $floor(x)$.

Description of Block 207.

In Figure 4, we present the proposed solution. A flow chart of Block 207 is shown in Figure 5. Below, we go through in detail the boxes in Figure 5.

Block 301: Sample the $i_I^{(CH)}$ and $i_Q^{(CH)}$ according to a predetermined pattern for physical channel CH. A given number of physical channels can be studied in parallel. We are interested in if either the I or Q part has saturated. We therefore compute the measurement quantity

$$\Omega^{(CH)} = \max(|i_I^{(CH)}|, |i_Q^{(CH)}|)$$

for each physical channel.

Block 302: Compute the expectation value of $\Omega^{(CH)}$. This can, for example, be done by filtering

$$\Omega_{n+1}^{(CH)} = (1-\alpha)\Omega_n^{(CH)} + \alpha\Omega^{(CH)}.$$

Here, the time constant for α, that is, the time it takes to compute the corresponding moving average, should be much larger than the time constant for the AGC loop. Furthermore, the time constant for α should be large enough to filter over a number of fading peaks and dips.

Block 303: This block is the core of the invention. We present four different methods for computing the reference value.

Algorithm I (Adjusts the reference value for Block 201): Let $\Omega_{ref}^{(CH)}$ be the reference value for $\Omega_n^{(CH)}$. Compute the new reference power value $P_{ref}^{(CH)}$ for the AGC using a PI controller, that is, calculate

$$e_n^{(CH)} = \Omega_{ref}^{(CH)} - \Omega_n^{(CH)},$$

$$I_{n+1}^{(CH)} = I_n^{(CH)} + \frac{1}{T_i} e_n^{(CH)}$$

Here $I_n^{(CH)}$ is stored from the last activation of the block and T_i is an integration constant. Take the new reference power for the AGC for channel CH as

$$P_{ref}^{(CH)} = K(e_n^{(CH)} + I_n^{(CH)})$$

for some constant K.

Usually, we have only one AGC and we set the final reference value as

$$P_{ref} = \min_{CH}(P_{ref}^{(CH)}).$$

Algorithm II (Adjusts the reference value for Block 204): Let $\Omega_{ref}^{(CH)}$ be the reference value for $\Omega_n^{(CH)}$. Compute the new reference scale value for Block 204, $S_{ref}^{(CH)}$, using a PI controller, that is, calculate

$$e_n^{(CH)} = \Omega_{ref}^{(CH)} - \Omega_n^{(CH)},$$

$$I_{n+1}^{(CH)} = I_n^{(CH)} + \frac{1}{T_i} e_n^{(CH)}$$

Here $I_n^{(CH)}$ is stored from the last activation of the block and T_i is an integration constant. Take the new reference scale value for Block 204 for channel CH as

$$S_{ref}^{(CH)} = K(e_n^{(CH)} + I_n^{(CH)})$$

for some constant K.

The truncation and saturation in Block 204 is then done as follows,

$$t_I^{(CH)} = sat(floor(g_I^{(CH)} \cdot S_{ref}^{(CH)})),$$

$$t_Q^{(CH)} = sat(floor(g_Q^{(CH)} \cdot S_{ref}^{(CH)})).$$

In algorithm I and II more general controllers can be used, but for ease of presentation we chose the simple PI controller.

Algorithm III (Adjusts the reference value for Block 201): The following algorithm is a simplified version of algorithm I. We assume that we have two reference power levels, P_1 and P_2. Do the following

$$\begin{aligned}
&\textbf{if } \Omega_n^{(CH)} > M_{t_I}(1-\gamma_1)\\
&\qquad P_{ref}^{(CH)} = P_1\\
&\textbf{elseif } \Omega_n^{(CH)} < M_{t_I}(1-\gamma_2)\\
&\qquad P_{ref}^{(CH)} = P_2\\
&\textbf{end}
\end{aligned}$$

Here, M_{t_I} denotes the maximum value represented by t_I, which is the same for t_Q. This algorithm toggles between two states. Here, $\gamma_1 < \gamma_2$ and $P_1 < P_2$. Having $\gamma_1 < \gamma_2$ introduces a viscosity to the system, which prevents us from toggling between the two reference values P_1 and P_2 from one activation of the block to the other.

Algorithm IV (Adjusts the reference value for Block 204): The following algorithm is a simplified version of algorithm II, similar in style to algorithm II. We assume that we have two reference scale levels, S_1 and S_2. Do the following

$$\begin{aligned}
&\textbf{if } \Omega_n^{(CH)} > M_{t_I}(1-\gamma_1)\\
&\qquad S_{ref}^{(CH)} = S_1\\
&\textbf{elseif } \Omega_n^{(CH)} < M_{t_I}(1-\gamma_2)\\
&\qquad S_{ref}^{(CH)} = S_2\\
&\textbf{end}
\end{aligned}$$

Here, M_{i_I} denotes the maximum value represented by i_I, which is the same for i_Q. This algorithm toggles between two states. Here, $\gamma_1 < \gamma_2$ and $P_1 < P_2$. Having $\gamma_1 < \gamma_2$ introduces a viscosity to the system, which prevents us from toggling between the two reference values P_1 and P_2 from one activation of the block to the other.

The truncation and saturation in Block 204 is then done as follows,

$$i_I^{(CH)} = sat(floor(g_I^{(CH)} \cdot S_{ref}^{(CH)})),$$

$$i_Q^{(CH)} = sat(floor(g_Q^{(CH)} \cdot S_{ref}^{(CH)})).$$

It is straight forward to generalize algorithm III and IV to include more power reference value levels.

Although a preferred embodiment of the present invention has been described and shown, the invention is not restricted to it, but may also be embodied in other ways within the scope of the subject-matter defined in the following claims.

Optimal scaling of RAKE output symbols for WCDMA

ABSTRACT

In a WCDMA receiver, we propose a method to adaptively select the reference power value for the AGC or to scale the despread data symbols provided from the RAKE unit with a reference scale factor before truncation and saturation. The reference power level and the reference scale factor depend on the strength of the signal output from the RAKE. With the proposed solution, we adjust the average size of the values output from the RAKE to obtain optimal performance.

Fig. 4 should be published.

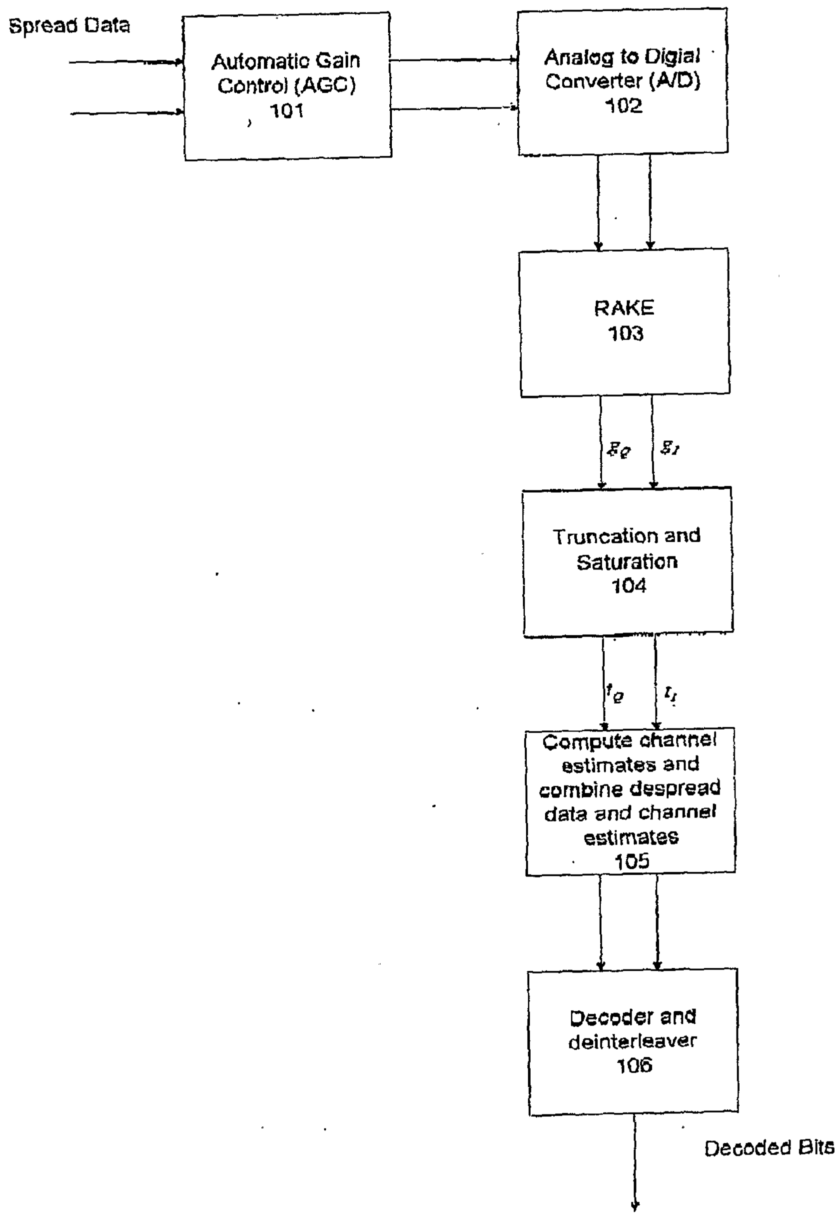
Spread Data
Automatic Gain Control (AGC) 101
Analog to Digial Converter (A/D) 102
RAKE 103
Truncation and Saturation 104
Compute channel estimates and combine despread data and channel estimates 105
Decoder and deinterleaver 106
Decoded Bits

Fig. 1

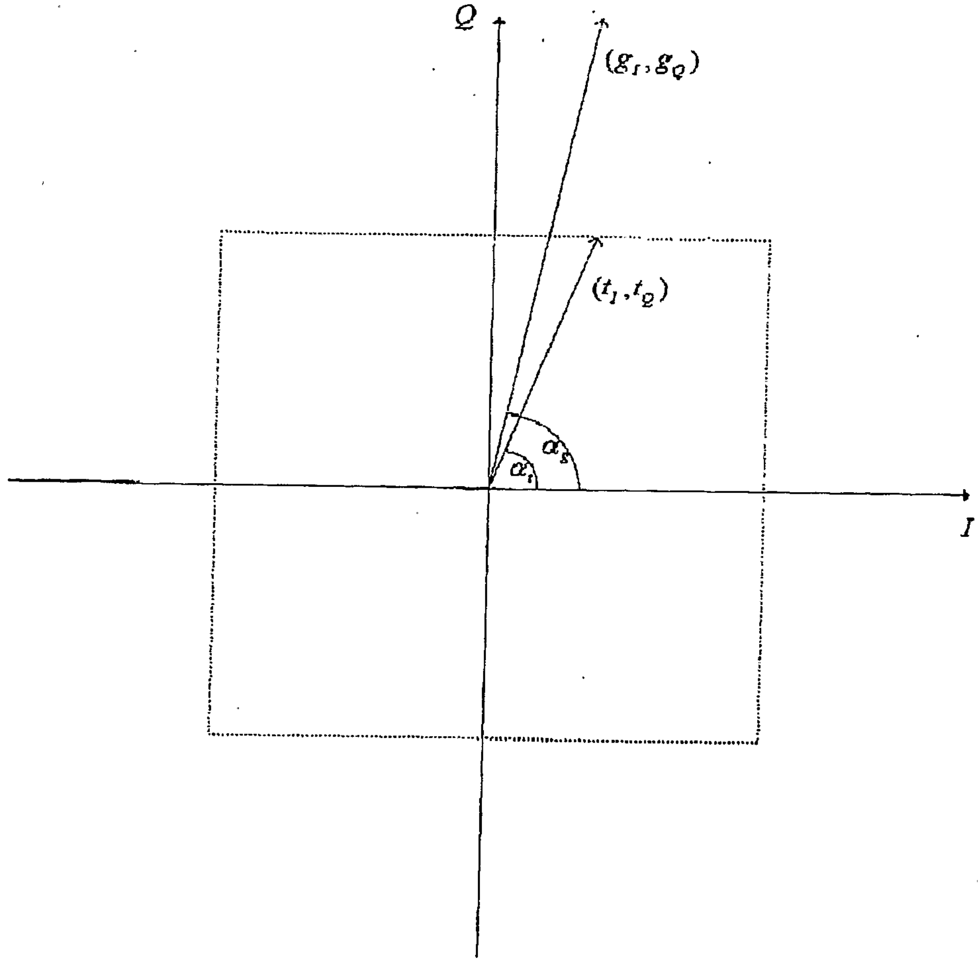

Fig. 2

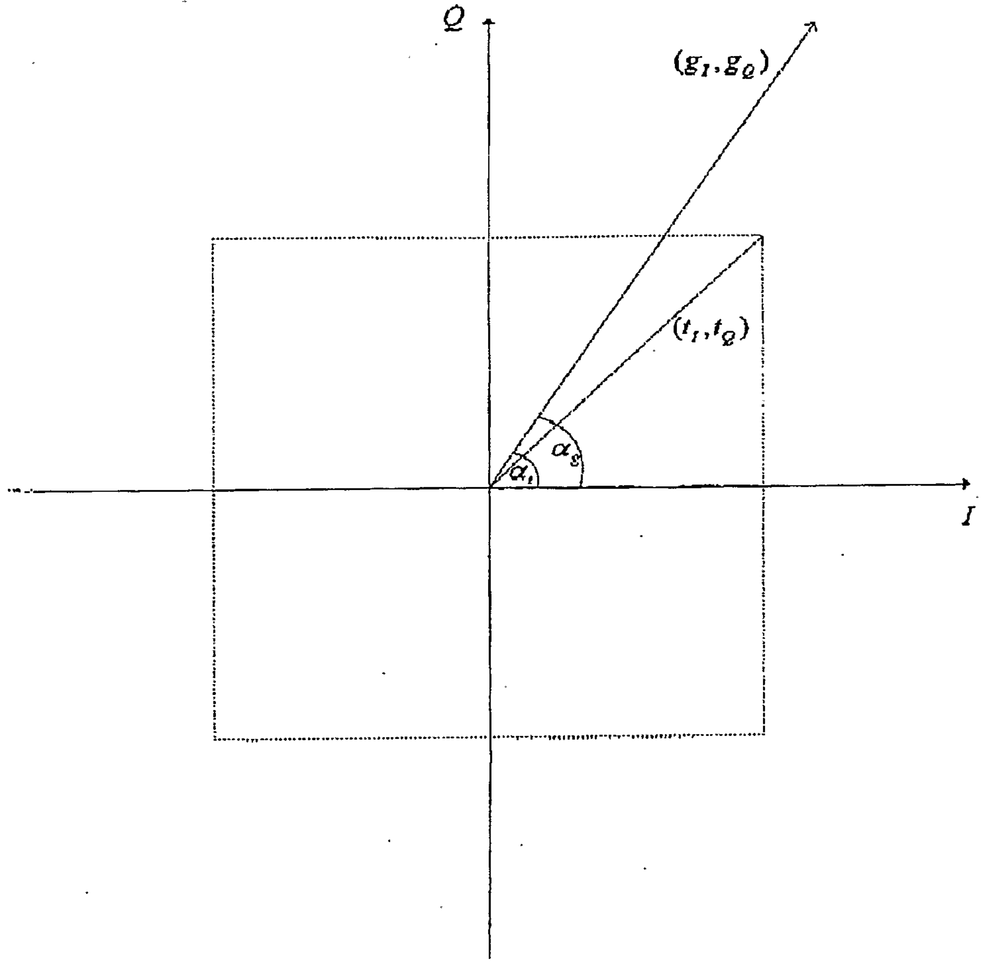

Fig. 3

4/5

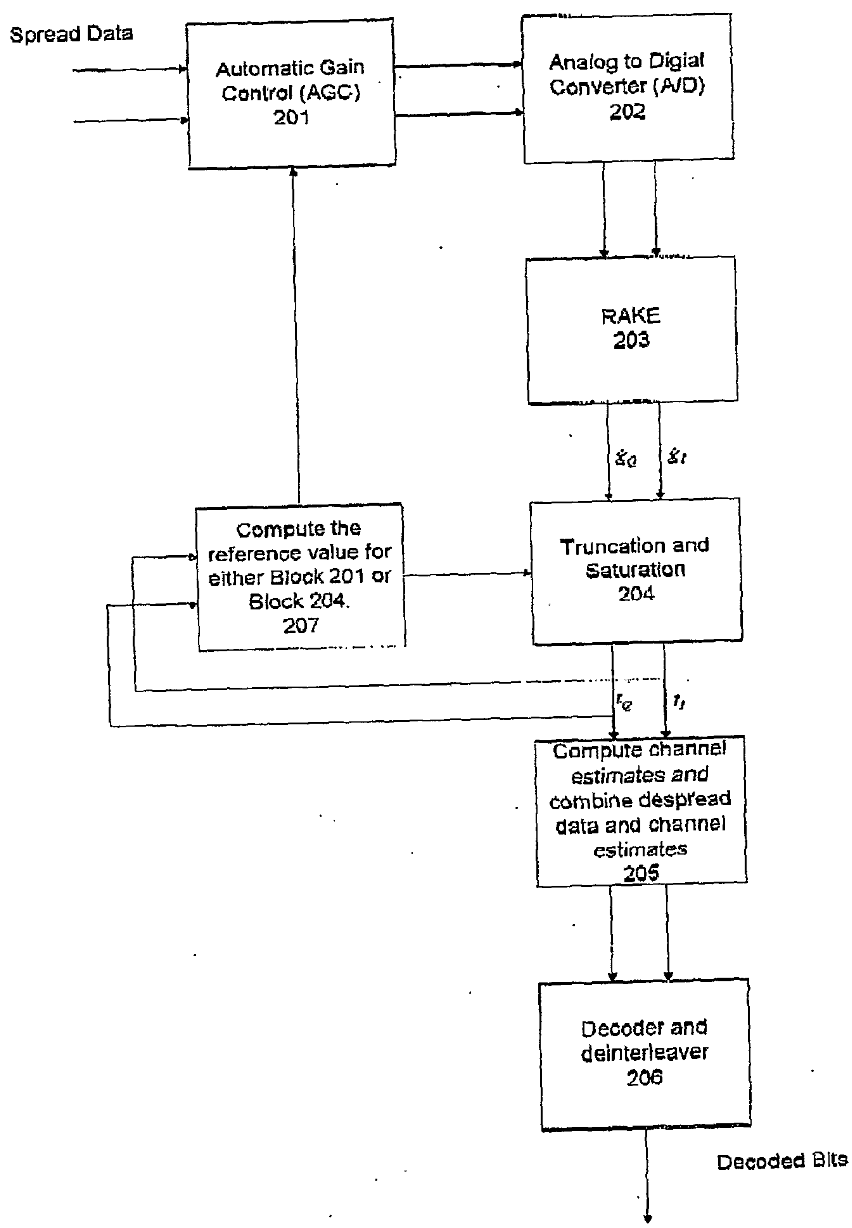
Spread Data
Automatic Gain Control (AGC) 201
Analog to Digial Converter (A/D) 202
RAKE 203
$\hat{s}_Q$
$\hat{s}_I$
Compute the reference value for either Block 201 or Block 204. 207
Truncation and Saturation 204
r_Q
r_I
Compute channel estimates and combine despread data and channel estimates 205
Decoder and deinterleaver 206
Decoded Bits

Fig. 4

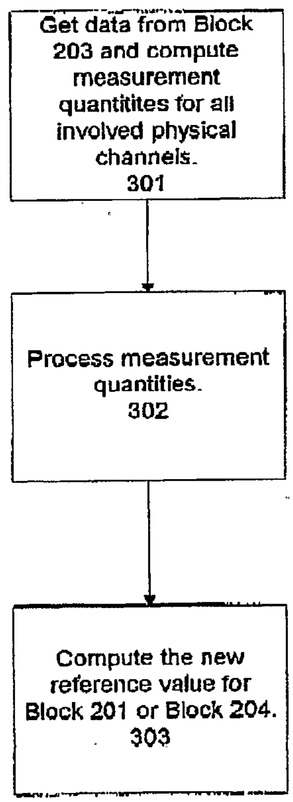
Get data from Block 203 and compute measurement quantitites for all involved physical channels.
301
Process measurement quantities.
302
Compute the new reference value for Block 201 or Block 204.
303

Fig. 5